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Partial Dislocations in the X-ray Topography of As-Grown Hexagonal Silicon Carbide Crystals

W.M. Vetter, M. Dudley (SUNY, Stony Brook)

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Introduction: Hexagonal silicon carbide crystals grown by the Lely and physical vapor transport (PVT) processes both contain dislocations whose Burgers vectors and line directions lie in the crystals' basal planes. In all hexagonal crystals, the basal plane is close-packed and the shortest lattice directions are $\frac{1}{3}\langle 11\bar{2}0\rangle$; therefore, slip is commonly observed along the basal plane in these directions. Dislocations of the $\frac{1}{3}\langle 11\bar{2}0\rangle(0001)$ slip system have been observed in transmission electron microscopy samples of hexagonal SiC that have been subjected to mechanical deformation. They normally exist as two Shockley partial dislocations that have dissociated as in the equation

$$\frac{1}{3}[11\bar{2}0] \rightarrow \frac{1}{3}[10\bar{1}0] + \frac{1}{3}[01\bar{1}0],$$

bounding a narrow strip of stacking fault with the displacement vector $\frac{1}{2}[0001]$, though in some circumstances perfect dislocations have been observed splitting into their partials. Dislocations of the same slip system typically appear in x-ray topographs of Lely platelets and PVT wafers. In these topographs they appear as perfect **b** = $\frac{1}{3}\langle 11\bar{2}0\rangle$ dislocations.

Methods and Materials: Topographic images were recorded on Kodak Industrex SR-1 X-ray film at a specimen-to-film distance of 10cm in the transmission geometry.

Results: In the Lely process, sublimated SiC forms platelets on the walls of a crucible. Basal plane dislocations that appear to radiate linearly outward from a platelet's point of wall contact in x-ray topographs are usually considered growth dislocations; those that curve about in the crystal are assumed to originate from mechanical deformation. Both types of basal plane dislocation display the same extinction behavior as the basal plane dislocations in PVT wafers: most of the dislocations visible in figures 1(a) through (c), which have diffraction vectors in the set $(11\bar{2}0)$, extinguish when the diffraction vector becomes $10\bar{1}1$ in figure 1(d).

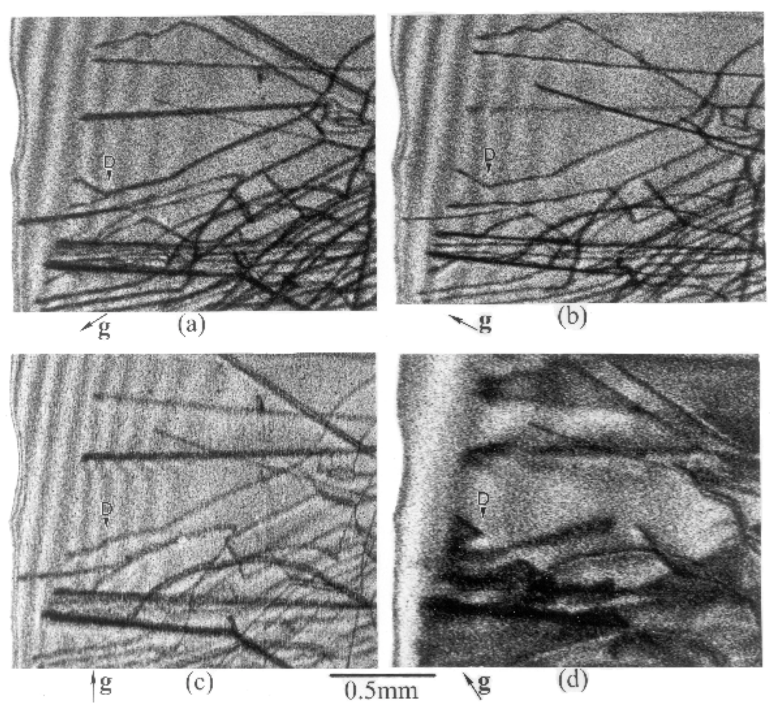

Figure 1. Synchrotron white-beam x-ray topographs of a 6H-SiC Lely platelet. **D** marks the point where a perfect dislocation dissociates into Shockley partials. The platelet's edge is on the topographs' left-hand sides; Pendellösung fringes run parallel to it. (a) **g** = $\bar{1}2\bar{1}0$ (λ = 0.59Å) (b) **g** = $11\bar{2}0$ (c) **g** = $2\bar{1}\bar{1}0$ (d) **g** = $10\bar{1}1$ (λ = 0.93Å).

It is rare to observe a **b** = $\frac{1}{3}\langle 11\bar{2}0\rangle$ dislocation in an x-ray topograph whose two partials are separated widely enough to be resolved. One exceptional case can be found in the center of figure 1(a). This dislocation has the Burgers vector $\frac{1}{3}[\bar{1}2\bar{1}0]$, because it extinguishes in 1(d). It originates at an optically visible flaw in the crystal outside and to the right of the area of platelet included in figure 1. At first it curves away from the flaw, then its line direction straightens to follow approximately the growth direction of the crystal, and its character becomes screw. At the point along its length labeled **D**, it dissociates into two partials with Burgers vectors $\frac{1}{3}[\bar{1}100]$ and $\frac{1}{3}[01\bar{1}0]$, each of which extinguish in either figure 1(b) or (c). The stacking fault that lies between them is visible in figure 1(d). Perhaps this is a special circumstance, as the apparent separation occurs about 0.2mm from the surface of the platelet, a region that represents growth during the cooling down phase of the furnace.

Conclusions: Considering that the dissociated state is what is generally observed by electron microscopy when dislocations are induced in hexagonal SiC by mechanical deformation, and that occasionally **b** = $\frac{1}{3}\langle 11\bar{2}0\rangle$ dislocations may be observed in x-ray topographs separating into their partials, it is probable that the **b** = $\frac{1}{3}\langle 11\bar{2}0\rangle$ dislocations observed in x-ray topographs are ordinarily represent pairs of closely-spaced partials.